Amendment to the Text:

Kindly amend page 14, beginning at line 1, and continuing to line 22, as follows:

$$f_p + f_c = f_c \frac{N_r}{N_p}, \text{ and} \tag{4}$$

$$f_s - f_c = f_c \frac{N_r}{N_s}. \tag{5}$$

Ignoring secondary transmission paths, the sun gear vibration is transmitted to the transducer mounted on the ring gear through the individual planets. The expected sun gear vibration signal measured by the transducer will thus be the sum of the sun gear vibration with each planet multiplied by the individual planet-pass modulations,

$$x_s(t) = \sum_{p=0}^{P-1} \alpha_p(t) v_{s,p}(t), \tag{6}$$

where $\alpha_p(t)$ is the amplitude modulation due to planet p_1 and $v_{s,p}(t)$ is the tooth meshing vibration of the sun gear with planet p. Alternatively, this can be expressed in the angle domain as

$$x_s(\theta) = \sum_{p=0}^{P-1} \alpha_p\left(\frac{N_s}{N_r}\theta\right) v_{s,p}(\theta), \tag{7}$$

where θ is the relative rotation of the sun with respect to the planet carrier[[.]],

p = planet

N_s = the number of teeth on the sun gear,

N_r = number of teeth on the ring gear,

$\nu_{s,p}(\theta)$ = the tooth meshing vibration of the sun gear with plane P

$\alpha_p(N_s/N_r\theta)$ = the amplitude modulation due to planet p.

Kindly amend page 15 beginning at line 1 and continuing to line 23, as follows:

Ignoring any slight variation between the planets, the amplitude modulation function (planet-pass modulation), $\alpha_p(\varphi)$, will have the same form of all planets, differing only by a phase delay, $2\pi p/P$,

$$\alpha_p(\varphi) = a\left(\varphi - \frac{2\pi p}{P}\right), \quad (8)$$

where $\alpha(\varphi)$ is the planet-pass modulation function, and φ is the planet carrier angle[[.]] , p is the planet, P is the number of planets. Since the amplitude modulation will repeat with the planet carrier rotation period, it can be expressed as a Fourier series,

$$a(\varphi) = \sum_{m=-\infty}^{\infty} A_m e^{im\varphi}, \quad (9)$$

where A_m are the Fourier series coefficients.

The method of extracting the representative vibrations of the sun gear "seen" through each planet (the "separated" sun gear averages) is to incorporate a selective

(continuous) time filter into the averaging process. The filter proportionally divides the overall vibration signal into the estimated contributions from each planet. For each separated sun gear average,

Kindly amend page 16, line 1, and continuing to line 14, as follows:

$\bar{z}_{s.p}(\theta)$, the filter window, $w(\theta)$, is centred at the point at which the planet is adjacent to the transducer. Assuming that all the vibration that is not synchronous with the relative sun gear rotation will tend toward zero with the averaging process (7 & 8), the synchronous average taken over N periods of the relative sun gear rotation can be expressed as

$$\begin{aligned}
\bar{z}_{s,p}(\theta) &= \frac{1}{N}\sum_{n=0}^{N-1} w\left(\frac{N_s}{N_r}(\theta+2\pi n)-\frac{2\pi p}{P}\right)x_s(\theta+2\pi n) \\
&= \frac{1}{N}\sum_{n=0}^{N-1} w\left(\frac{N_s}{N_r}(\theta+2\pi n)-\frac{2\pi p}{P}\right)\left[\sum_{k=0}^{P-1} a\left(\frac{N_s}{N_r}(\theta+2\pi n)-\frac{2\pi k}{P}\right)v_{s,k}(\theta+2\pi n)\right] \quad (10) \\
&= \sum_{k=0}^{P-1}\bar{v}_{s,k}(\theta)\frac{1}{N}\sum_{n=0}^{N-1} w\left(\frac{N_s}{N_r}(\theta+2\pi n)-\frac{2\pi p}{P}\right)a\left(\frac{N_s}{N_r}(\theta+2\pi n)-\frac{2\pi k}{P}\right),
\end{aligned}$$

where $\bar{v}_{s,k}(\theta)$ is the mean vibration of the sun gear with planet k[[.]], θ is the relative rotation of the sun with respect to the planet carrier, $x_s(\theta)$ is the expected sun gear vibration signal, N_s is the number of teeth on the sun gear, N_r is the number of teeth on the ring gear, $w(N_s/N_r\theta)$ is the planet separation window function, $a(N_s/N_r\theta)$ is the planet-pass modulation function, $v_{s,k}(\theta)$ is the tooth meshing vibration of the sun gear with planet k, $\bar{v}_{s,k}(\theta)$ is the mean

<u>vibration of the sun gear with planet k, and P is the number of planets.</u>

With careful selection of the window characteristics and the synchronous averaging parameters, the separation can be performed with a minimum of "leakage" of vibration from the other planets (note that even if the window completely separates the vibration of the sun gear with each planet, this will not totally eliminate the influence of the sun gear meshing with the other planets since there will still be transmission paths from those meshes through the sun

Kindly amend page 21, line 1, and continuing to line 20, as follows:

Equations 1 and 2, which are repeated here for convenience.

$$w_{power}(t)=\left(\frac{1}{2}+\frac{1}{2}\cos(2\pi f_c t)\right)^{P-1}\text{, and } w_{sum}(t)=\frac{1}{2}+\sum_{m=1}^{P-1}\cos(2\pi m f_c t).$$

Applying the new sun gear averaging technique described in §2 to Equation 16, the modified sun gear average, $\tilde{z}_{s,m}(\theta)$, can be expressed as

$$\bar{z}_{s,m}(\theta)=\sum_{p=0}^{P-1}\sum_{k=0}^{P-1}\bar{v}_{s,k}\left(\theta-\frac{2\pi p}{P}\right)\left[W_0A_0+2\sum_{l=1}^{P-1}W_lA_l\cos\left(l(k-p)\frac{2\pi}{P}\right)\right], \tag{18}$$

whereby the delay, $2\pi p/P$, aligns the mean sun gear vibration with each planet, $\check{v}_{s,k}(\theta)$, so that the beginning of each separated average starts with the same sun gear tooth in mesh with each planet[[.]]<u>, and θ is the relative rotation of the sun with respect to the planet carrier, p, k and l are summation indicies, P is the number of planets, W_0 and W_1 are the Fourier coefficients of the planet separation window function, A_0 and A_1 are the Fourier coefficients of the planet-pass modulation function.</u>

If the sun gear vibrations with each planet were identical, they would repeat with a period of $2\pi p/P$, i.e.,

$$v_{s,p}(\theta) = v_s\left(\theta + \frac{2\pi p}{P}\right), \tag{19}$$

Kindly amend page 22, line 1, and continuing to line 23, as follows:

where v_s is the meshing vibration of the sun gear with a planet. Substituting Equation 19 into Equation 18 results in

$$\begin{aligned}\bar{z}_{s,m}(\theta) &= \bar{v}_s(\theta)\sum_{p=0}^{P-1}\sum_{k=0}^{P-1}\left[W_0 A_0 + 2\sum_{l=1}^{P-1} W_l A_l \cos\left(l(k-p)\frac{2\pi}{P}\right)\right] \\ &= PW_0 A_0 \bar{v}_s(\theta),\end{aligned} \tag{20}$$

θ is the relative rotation of the sun with respect to the planet carrier, p, k and l are summation indicies, P is the number of planets, W_0 and W_l are the Fourier coefficients of the planet separation window function, A_0 and A_l are the Fourier coefficients of the planet-pass modulation function, and $\bar{v}_s(\theta)$ is the mean vibration of the sun gear with a single planet,

and the modified sun gear average would thus represent, to within a constant, the average vibration of the sun gear with a single planet. However, since the sun gear vibration will, in practice, not be identical with each planet, the modified average will only tend to average-out the differences between the meshing behaviour with each planet. Nevertheless, because the separated

averages will be aligned at the same sun gear tooth, any localized sun gear defect will always appear at the same angular position, and thus be reinforced. This should lead to an improved ability to detect the fault compared to an ordinary sun gear average, where the influence of the defect will be more distributed.